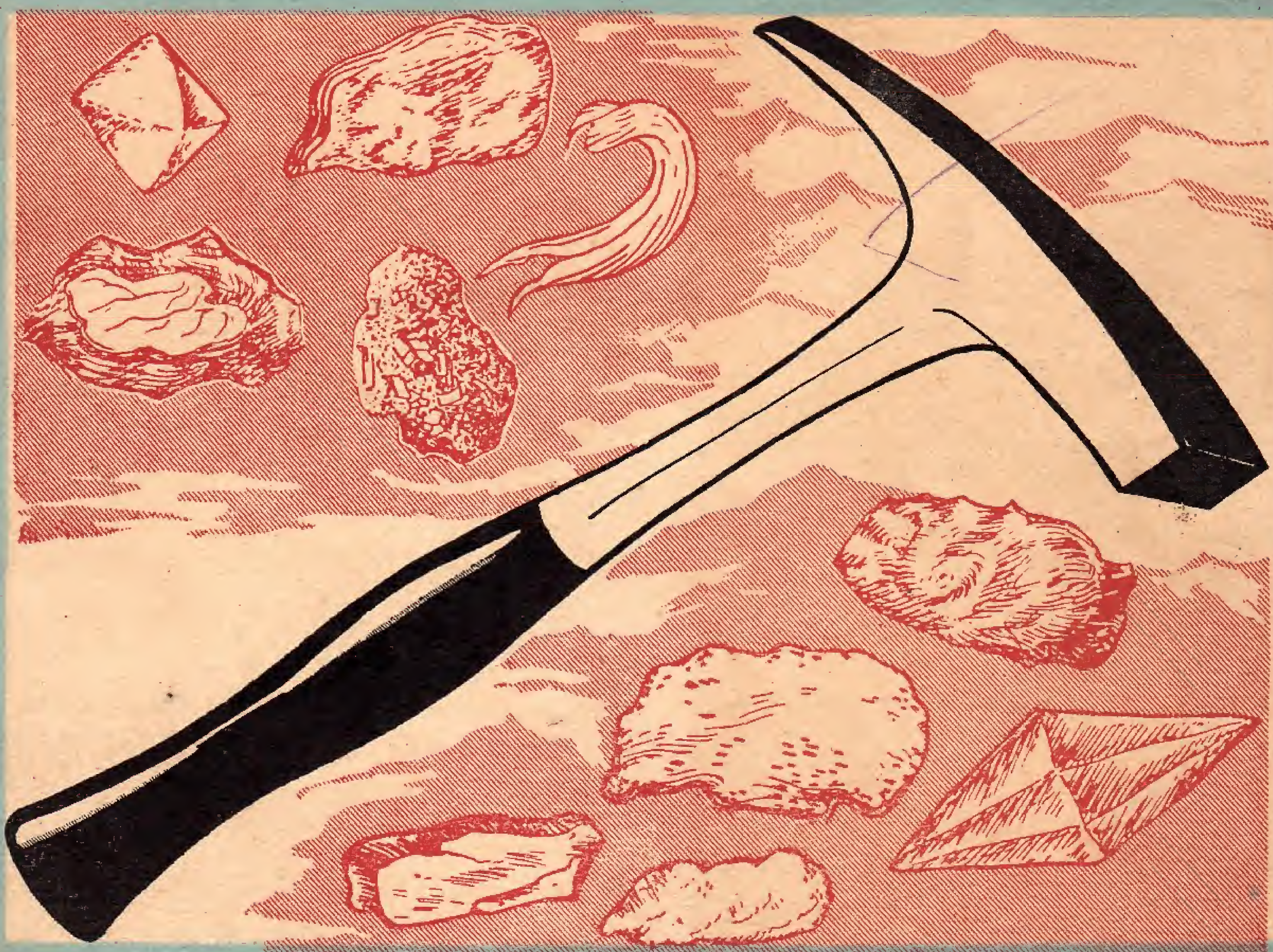
SACHITRA

BIGYAN

KOSH

Illustrated Science and Technology

STORY OF MINERALS AND METALS



No. II

JATIYA SANSKRITI PARISHAD

The publication of a series of booklets giving latest information on Science and Technology meets the Parishad's long-nourished wish to spread scientific knowledge among the wider population through the medium of visual aids.

Each booklet will present the basic concepts and the latest findings of science and technology. These will grow into an encyclopedia.

By the standard attained, these booklets can reasonably be taken as authoritative reference and would satisfactorily answer the scientific quest of all in simple ways.

Each will relate the relevant information, all inside one booklet. You do not have to go searching for bits of information scattered in many publications.

Each of the booklets will contain nearly 40 illustrations to supplement the text.

We believe this ambitious publishing project of Jatiya Sanskriti Parishad will have the support of all.

Production : Progressive Publicity Service, 14 Bentinck Street, Calcutta 1.

Printed by : Asish Sinha at Display Printers, 16/3 Gariahat Road, Calcutta-19.

Published by : Dhirendra Chandra Sinha on behalf of Jatiya Sanskriti Parishad from 16/3 Gariahat Road, Calcutta-19.

Price : One Rupee

Monday, 16th November, 1964

OUR EARTH

Our earth is a huge ball of rock. Can you imagine how heavy it is ?

The earth weighs about 6,600,000,000, 000,000,000,000 tons. Its diameter through the equator is 7,926.68 miles, but from pole to pole the diameter is 7,899.98 miles, or 26.7 miles less. Our earth is in fact 'pear-shaped'. This startling fact has been revealed by an artificial satellite only a few years ago.

All life is spread out in a thin layer on, or close to the surface of the rocky earth. Some plants and animals make their homes two or three miles above sea level. Others can survive an equal depth below the surface of the sea. But within this thin six-mile layer, all plants and animals live, grow and die.

The story of where rocks come from is closely related to the origin of the earth, and this mystery is yet to be unveiled. The best guess is that the earth and the entire solar system have been in existence for a little over four billion years.

Our direct knowledge of rocks is limited pretty much to the crust of our earth. The deepest hole that man has ever been able to dig in it is a Texas oil well in America that goes 25,340 feet deep. Incidentally, Mt. Everest, 29,002 feet high, is the earth's highest mountain.

Scientists can measure the age of rocks that contain uranium quite accurately. Uranium in a rock slowly but steadily changes to one kind of lead. When about

The Earth as we see it

one quarter of the uranium has changed to lead, two billion years have passed. This is almost the age of the oldest known rocks, found in the mountains of India.

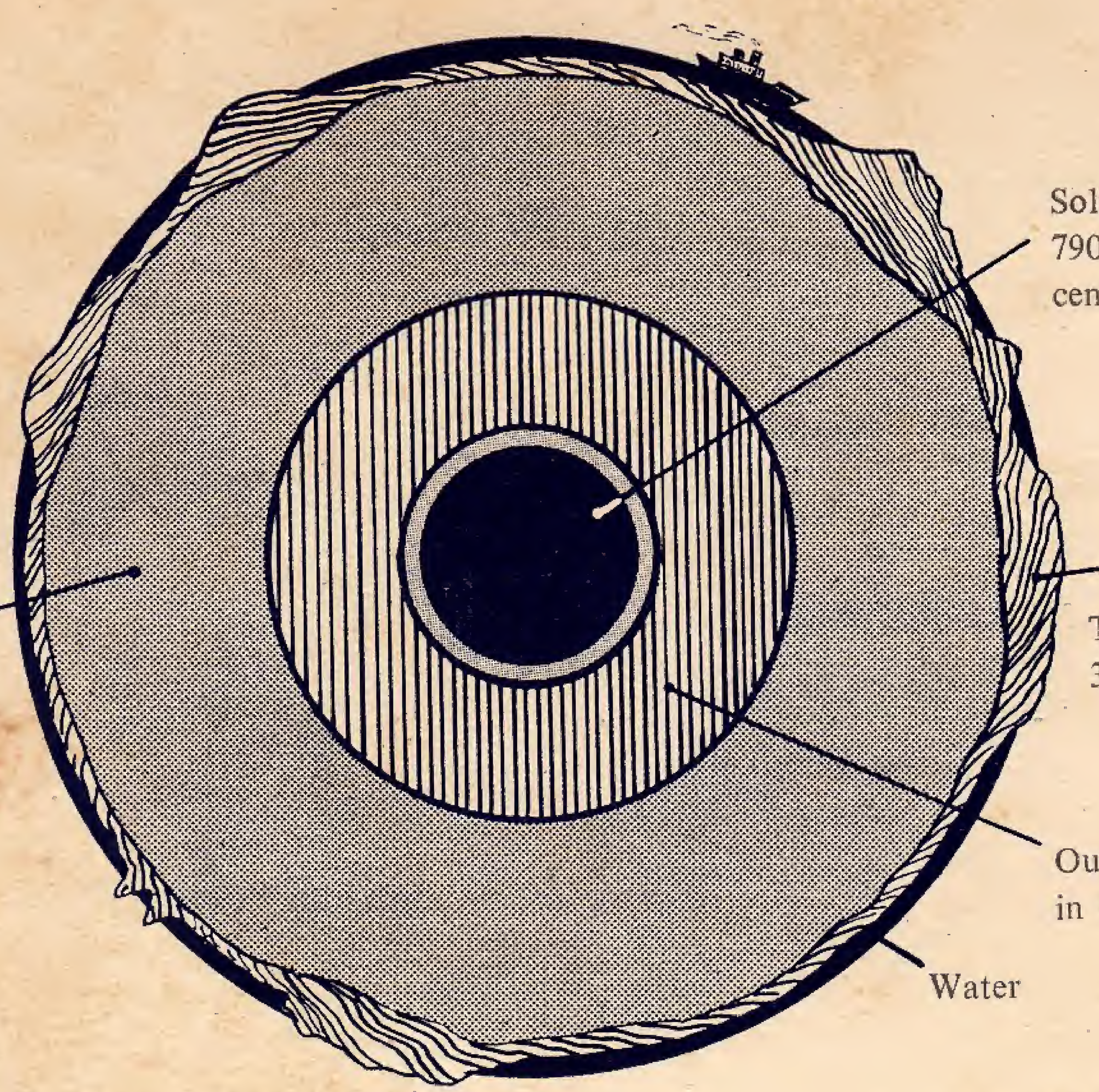
Astronomers and geologists agree that the earth, the planets and the sun are made of *matter*. Hence, understanding what is meant by matter is the first step in understanding rocks.

Matter is anything which occupies space, has weight and can be detected by some means or another. All matter is made of about 100 different chemical elements. Over 99 per cent of the material in the earth is made of the 30 lightest elements. All our rocks are made of these 30 light elements. Thousands of kinds of minerals are known, but only a hundred or so are common. These common kinds are made mainly of eight elements—oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium.

These eight elements joined together in various ways, make up nearly 99 per cent of the crust or outer part of the earth.

The branch of science that deals with the study of earth is called *geology* (from the Greek *ge* means earth and *logos* means science).

In an age of rockets and missiles, the study of rocks and minerals and metals is no less important. Our modern age of rockets and missiles would not even be possible without rocks and minerals.



Interior of the earth

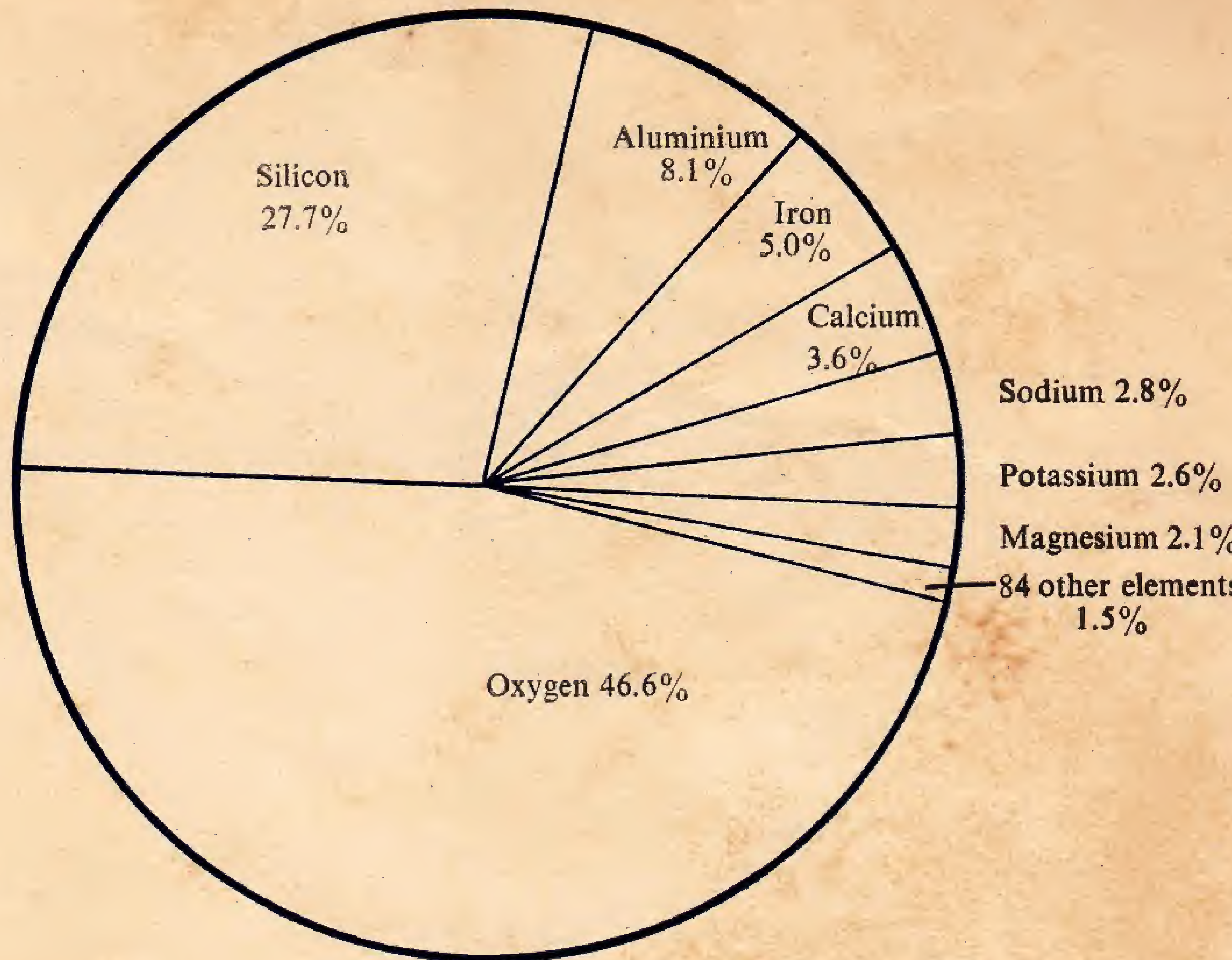
EARTH'S CRUST

The thin outer shell of the earth is called *crust*. The top layer of the crust, in land areas, is generally covered with soil. The crust of the earth extends downward for only about twenty miles, on the average, in continental areas and only about five miles below the main ocean floors.

Below the crust lies the more or less mysterious interior of the earth. We have no first-hand information of this region, we are to rely on indirect evidence in studying it.

The interior of the earth consists of two main regions--a nickel-iron central core, with a diameter of about 4,400 miles, and a surrounding mantle, about 1800 miles thick.

Scientists have calculated the density of the earth's interior at various levels, its temperature and its elasticity ; they have also made an analysis of the composition of the materials contained in these lower regions.



There are eight elements joined together in various ways, make up nearly 99% of the crust of the earth.

Rocks

The earth's crust is made up of rocks, which consists of various minerals. There are many kinds of rocks. Very small rocks are called sand. Rocks bigger than sand have other names like pebbles or stones. They have different shapes and sizes, some like a ball or some like a block. They are of many colours and found almost everywhere. Rocks may be divided into three basic types : *igneous*, *sedimentary* and *metamorphic*.

IGNEOUS ROCKS

The word igneous means made from fire or heat. So the rocks produced by fire or heat are called igneous rocks.

Deep down in the earth it is very hot. That heat has changed the rocks and minerals there into molten rock, called ***magma***. When the magma comes up to the surface of the earth, it cools off and becomes hard. The cold magma, hardened into rock, is called igneous rock (as in the case of basalt).

Sometimes the magma does not get all the way up to the earth's surface. It cools underneath the ground, turning into rock before it gets up to the surface. This kind of igneous rock is called granite.

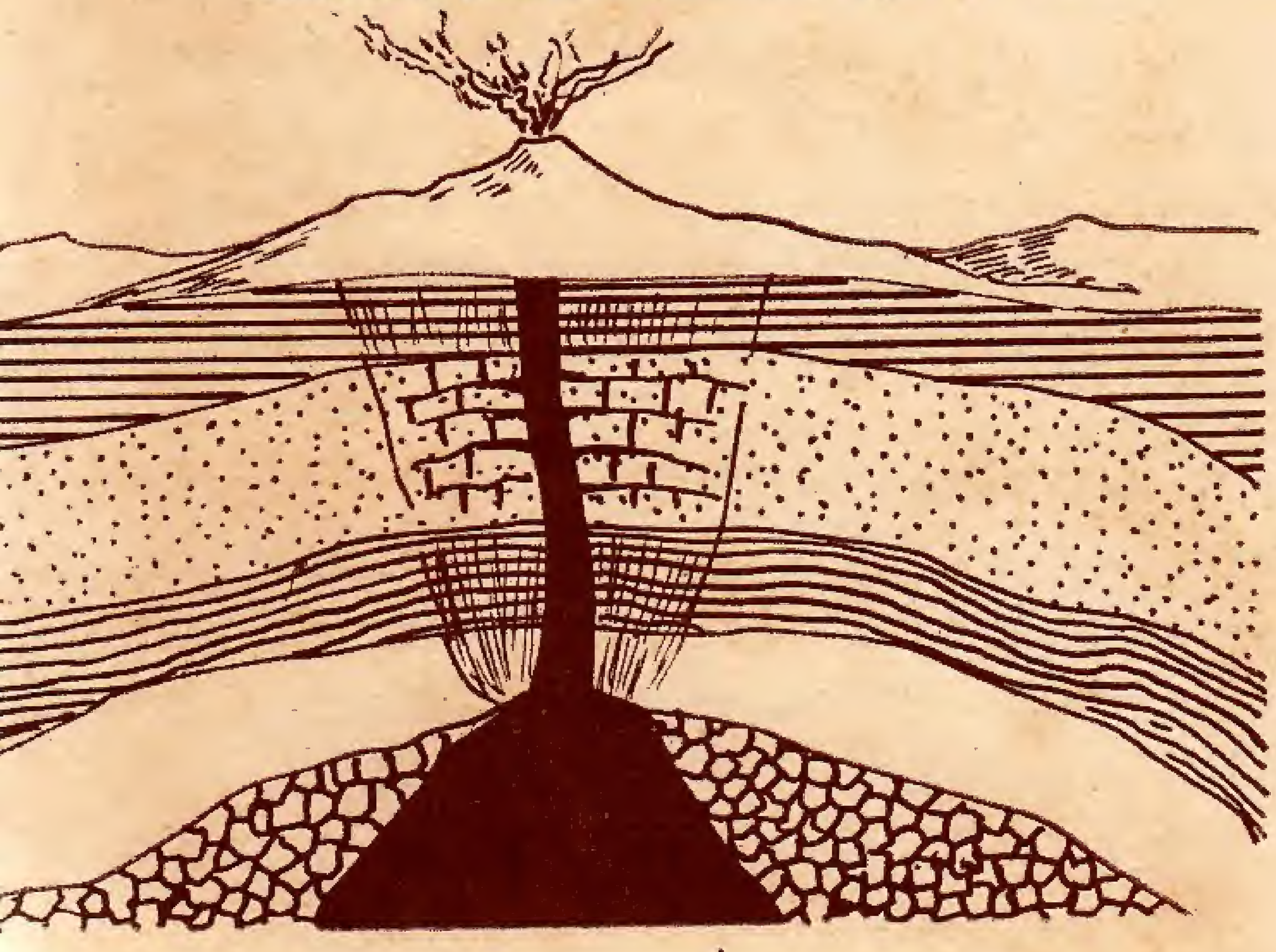
There are many kinds of igneous rocks such as diorite, felsite, obsidian etc.

Lava flowing down from a volcano. In time the molten lava cools and hardens into igneous rock.

SEDIMENTARY ROCKS

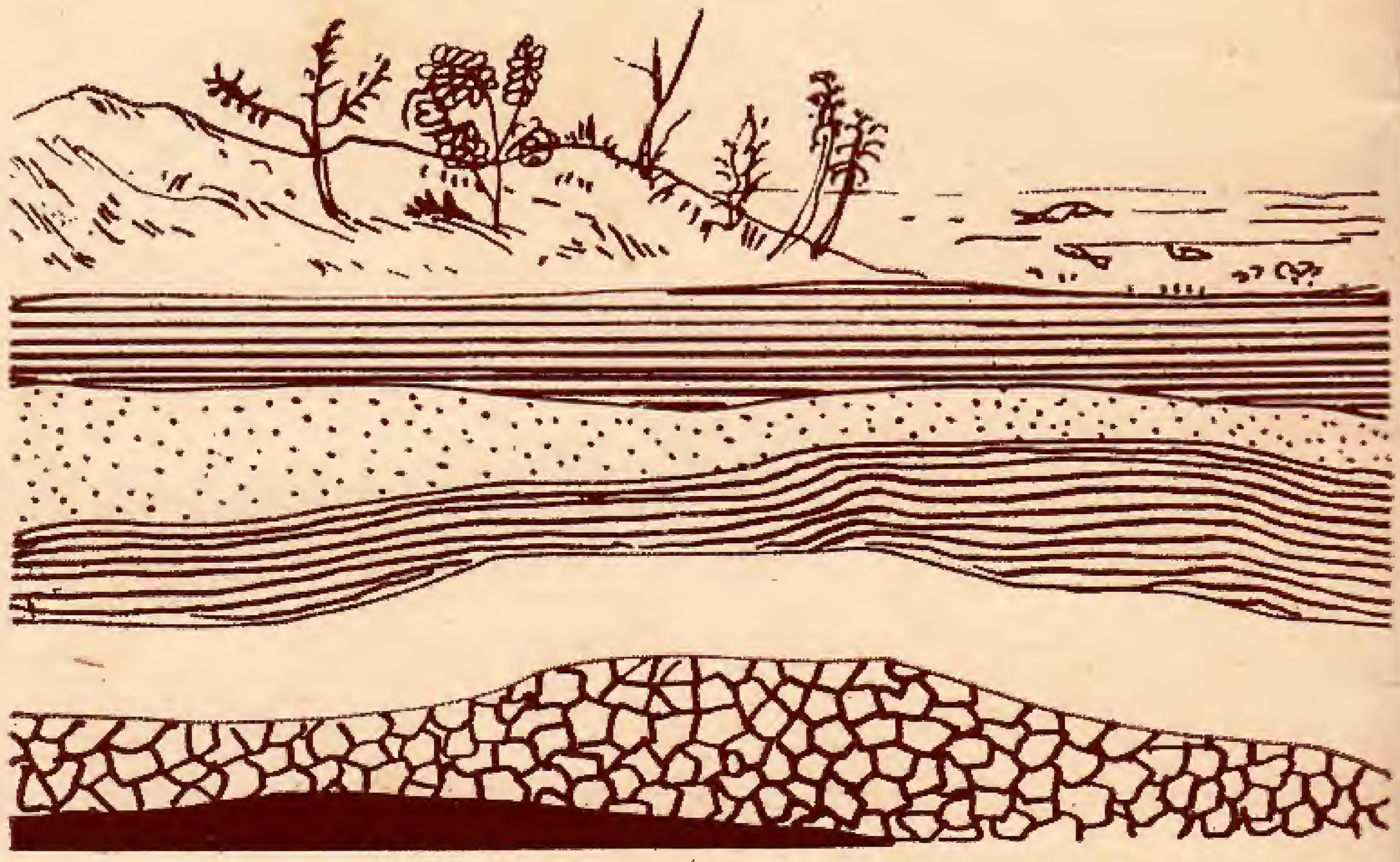
If you mix up a handful of dust in a glass of water, the water becomes cloudy. But if the water is left alone, the dust will settle to the bottom of the glass and the water will be clear again. The dust that has settled to the bottom of the glass is called *sediment*. From this word comes the name sedimentary.

Metamorphic rocks occur as a result of the heat and pressure on other types of rocks.



Sedimentary rocks are derived from rock fragments, moved and spread by wind, water and other agencies. Every day the streams and rivers bring more and more mud, sand and rock to the seas. The big rocks sink and settle first because they are heavier. Next the sand and then the mud sinks to the bottom of the sea. In this way different layers are built up.

The weight of the layers and water above press down on the bottom and the bottom layers begin to change. Each tiny grain of sand begins to stick to another one and the sand grains change into stone. Because the stone is made from sand, it is known as sandstone, a kind of sedimentary rock.



Sedimentary rocks are made up of particles of older rocks.

Sometimes sedimentary rocks are made on dry land. Many volcanoes blew out ashes and volcanic dust which settled around them. In time they change into rocks.

Besides these, some sedimentary rocks were made from the shells of sea animals and plants. When a plant or animal dies, its shell sinks to the bottom of the sea. After many years, millions of dead shells pile up on the bottom of the sea. The weight of the shells on top changes the

bottom layer of shells. In times they become stone. This is known as limestone, another kind of sedimentary rock. Both plants and animals have contributed to the formation of coral reefs and islands.

Among the most important sedimentary rocks are conglomerate, sandstone, shale, limestone and dolomite.

FOSSILS

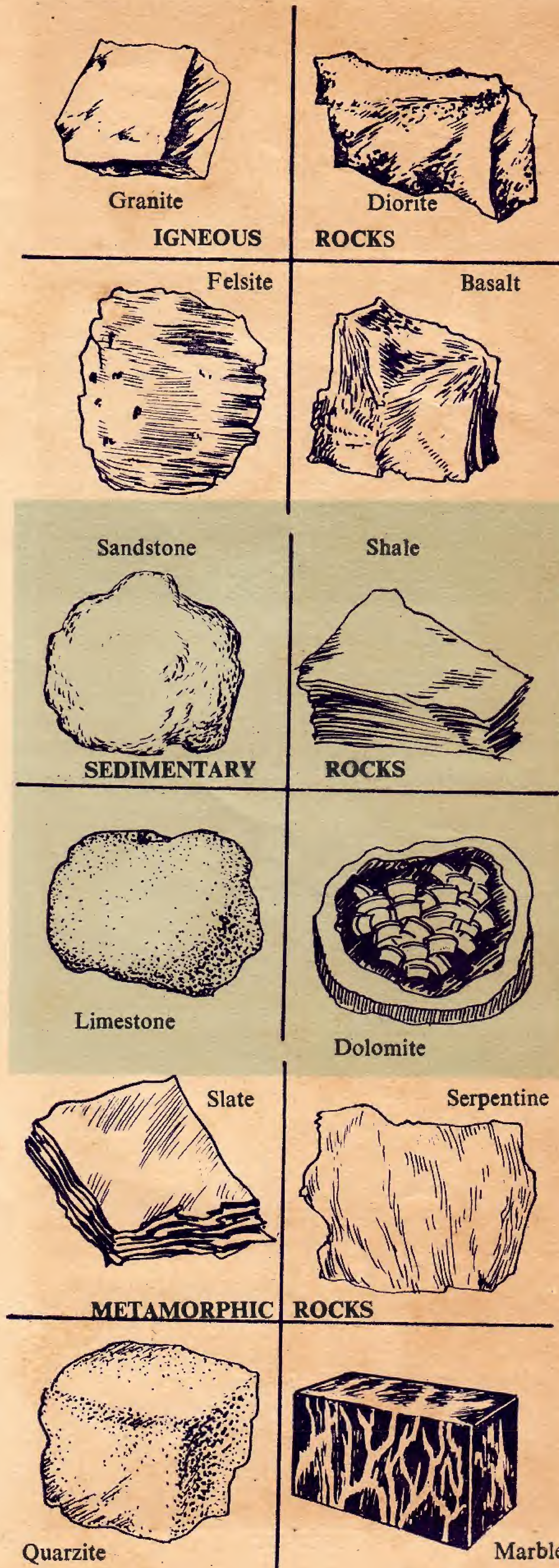
The plant and animal remains and imprints—the so-called *fossils*—contained in sedimentary rocks reveal a great deal about its formation. Sediments deposited on land would ordinarily contain fossils of land animals and plants ; those deposited in the sea would contain the shells of marine animals. The fossils offer priceless information about the history of plant and animal life on the earth.

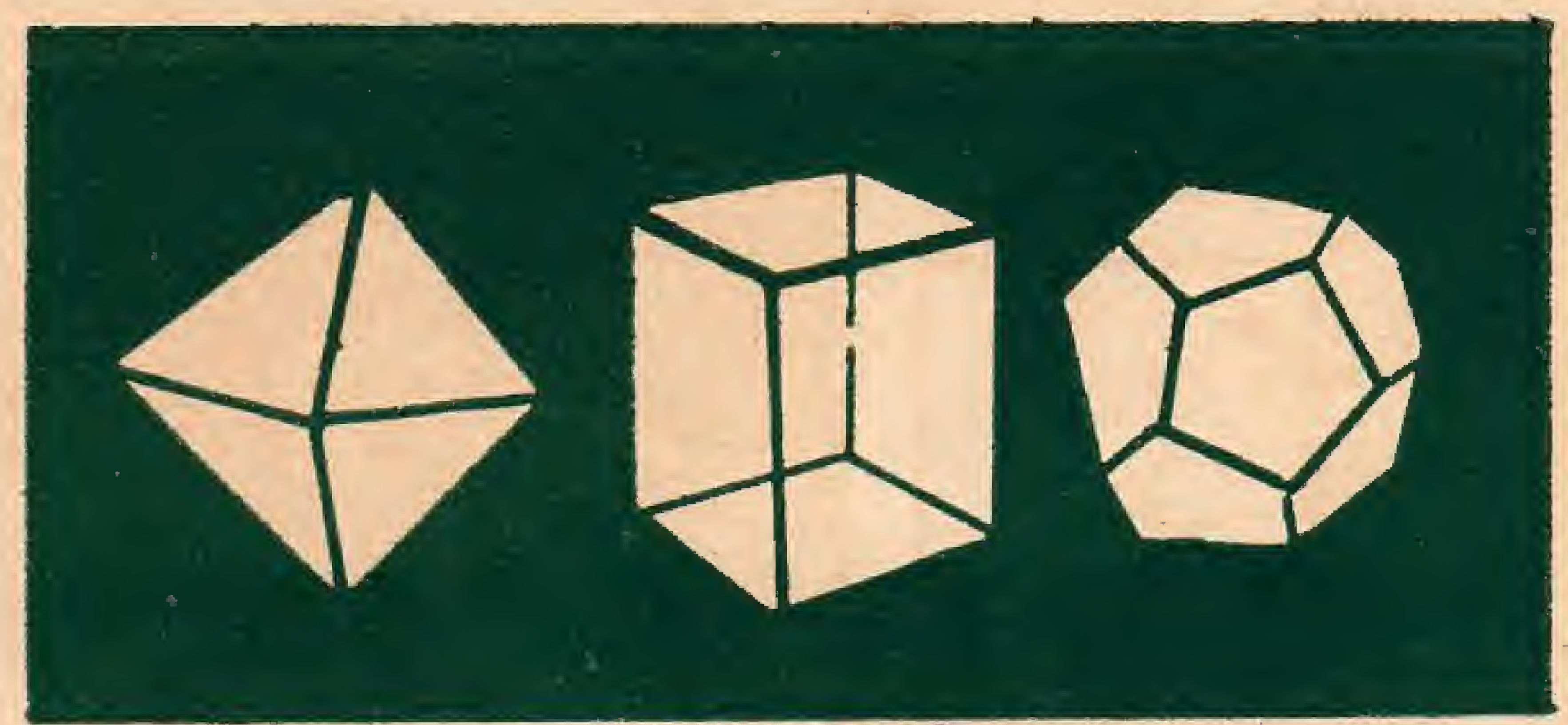
METAMORPHIC ROCKS

The name metamorphic means to have been changed. The rocks of the third main division—the metamorphic rocks—are made up of igneous or sedimentary rocks that have been changed in the course of the ages. Various factors enter into metamorphism, or the formation of metamorphic rock : pressure, heat, the presence of water, chemical changes. The particles of the original rock are forced into new arrangements ; new minerals may be formed. The new rocks do not look the same, for in becoming metamorphic rocks their structure and often their colour change.

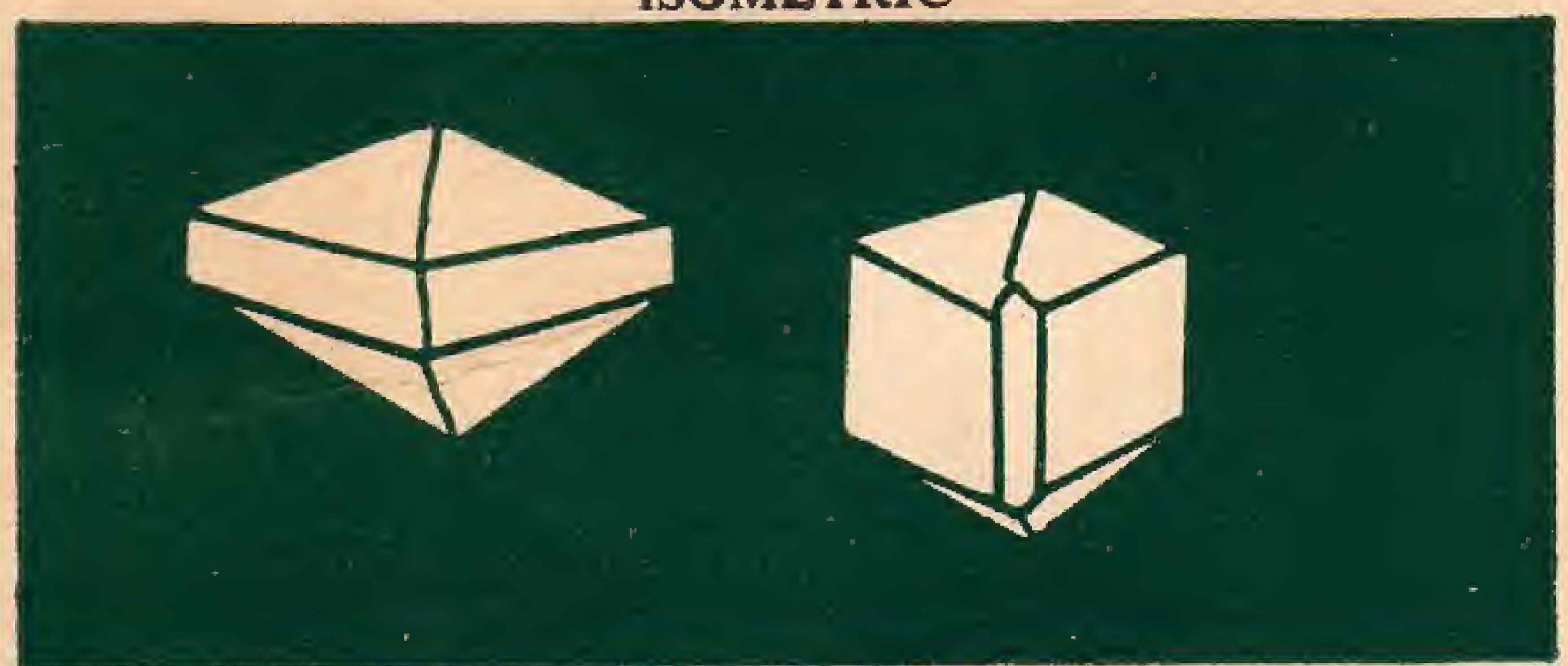
When limestone is changed, it turns into marble. If shale is changed, it turns into slate. Schist is derived from mudstone or shale ; quartzite is made from sandstone.

Thus marble, slate, schist, quartzite are all metamorphic rocks.





ISOMETRIC

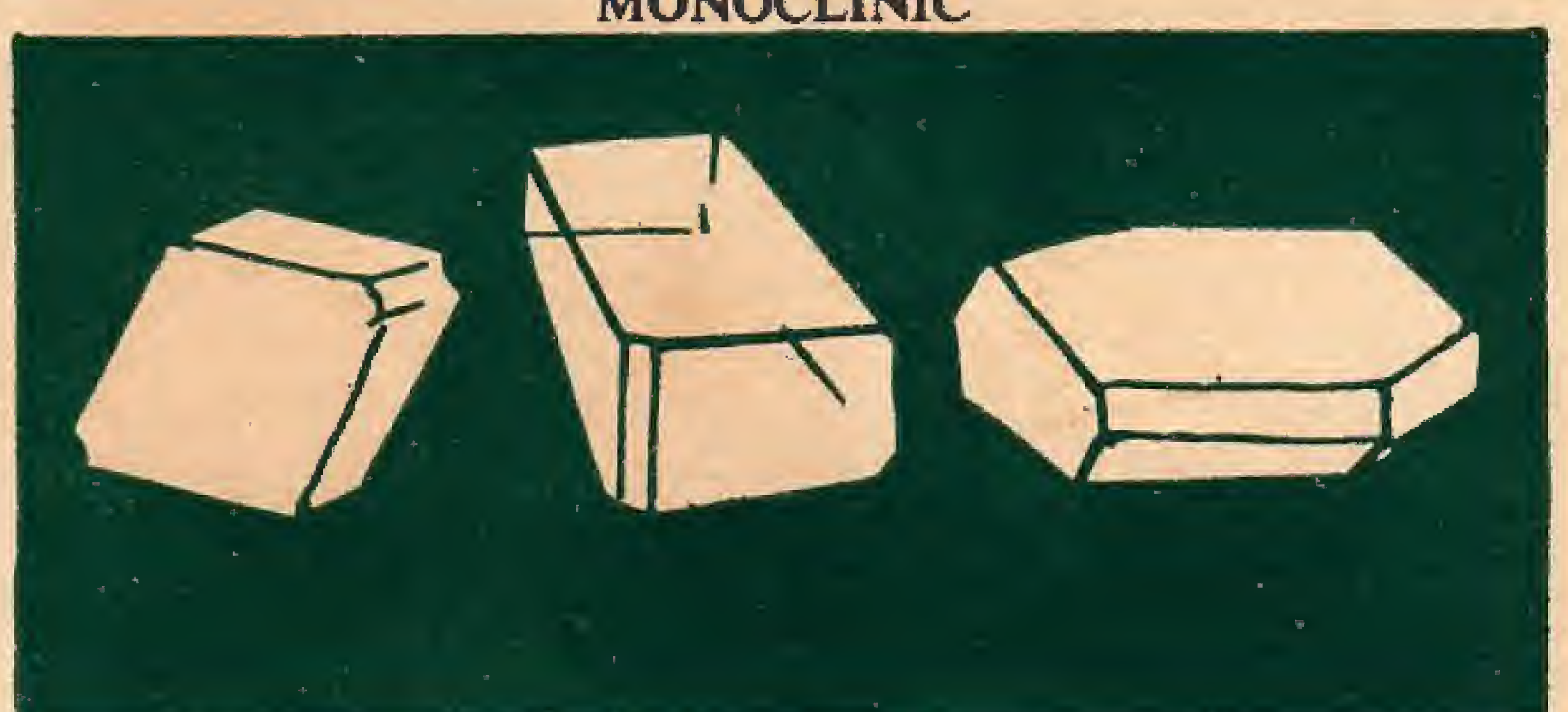


TETRAGONAL

HEXAGONAL

ORTHORHOMBIC

MONOCLINIC



TRICLINIC

CRYSTALS

There are non-living substances which grow into bodies of various shapes. They grow by adding on more layers of the same substance, keeping the same shape at all times. These bodies of various shapes are called crystals. Crystals are really another form of rocks and minerals, except that the word 'crystal' tells us that the rock or mineral is of a certain shape.

Crystals have been classified on the basis of their external forms. There are thirty-two classes in all in this classification, and they are grouped in six major divisions, called *systems*. The systems are based on the arrangement of three (or, in one system, four) imaginary axes that intersect at a point within the crystal.

However, six major systems of crystals are : (1) *Isometric* (*cubic*) system, (2) *Tetragonal* system, (3) *Hexagonal* system, (4) *Orthorhombic* system, (5) *Monoclinic* system, (6) *Triclinic* system. The differences between the various systems are brought out in the drawings on this page.

Our Earth is mainly made up of :

Molten Iron	—	35.0	per cent
Solid Rock	—	64.6	,, ,,
Granite	—	0.36	,, ,,
Sedimentary Rock	—	0.016	,, ,,
Sea	—	0.024	,, ,,

Classification of Crystals

Minerals

We can define a mineral as a naturally occurring inorganic (nonliving) chemical compound or element. By 'naturally occurring' we mean that a substance must be found in the soil, rocks or waters of the earth and that it cannot be something in the formation of which man had a hand. Minerals are all around us and they are easily found almost everywhere. In fact, it may be said that anything that is not an animal or vegitable is a mineral.

Almost all minerals are solid. But water is a liquid mineral. Some other minerals are clay, chalk and oil. Metals such as iron, gold, silver are minerals. Some minerals are found on top of the ground. Others are dug up from under the ground. All minerals do not come from mines. Some of our important minerals come from the sea such as salt.

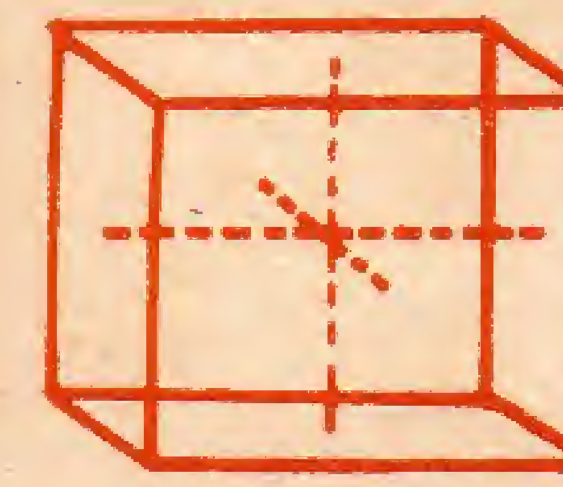
How minerals are formed

Mineral is the net result of natural forces acting on earth matter in an area through a given length of time.

Minerals are formed in various ways. Some are made directly from magma such as quartz, micas, feldspars etc. Other may be deposited as solids directly from the gaseous state, around volcanic openings. Salt and sulfur are good examples of these kinds. Gold and some other minerals are precipitated substances from solution in hot magmatic waters.

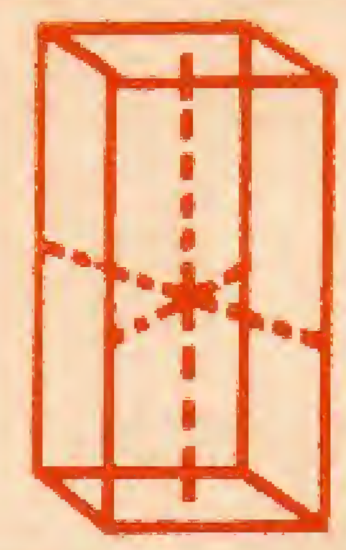
Some mineral deposits have been formed as worm or cold circulating waters have dropped their loads of dissolved mineral matter in a crack in the rock. These are called vein minerals. Gold, quartz, sulfides are examples of these vein minerals.

Gypsum is a familiar example of minerals those were originally in solution in bodies



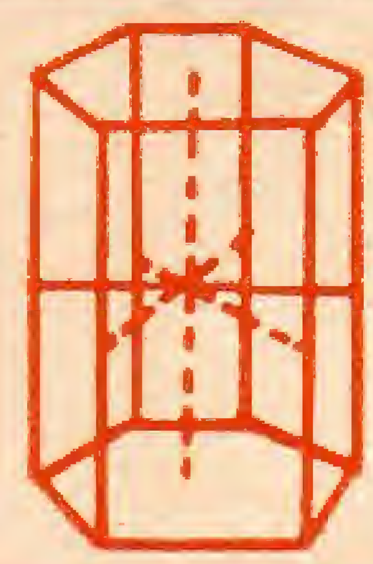
ISOMETRIC

In these crystals, the three axes are of equal length and at right angles to one another.



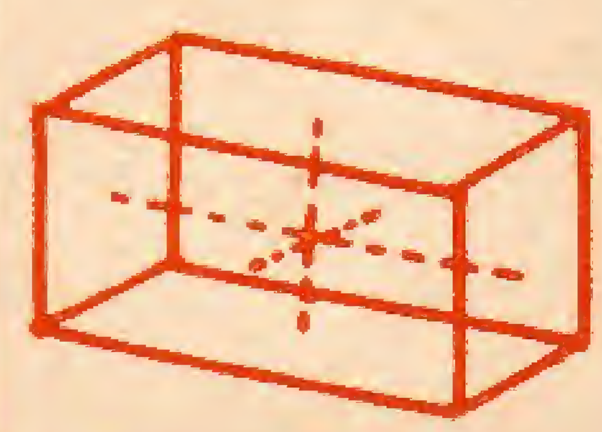
TETRAGONAL

Here the axes are at right angles to each other. Two axes are of equal length. The third may be either shorter or longer.



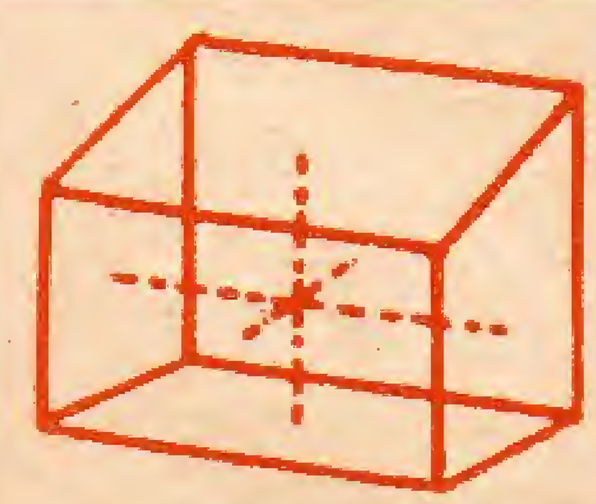
HEXAGONAL

These are crystals with four axes. Three are of equal length and horizontal. The fourth one is at right angles to the other three.



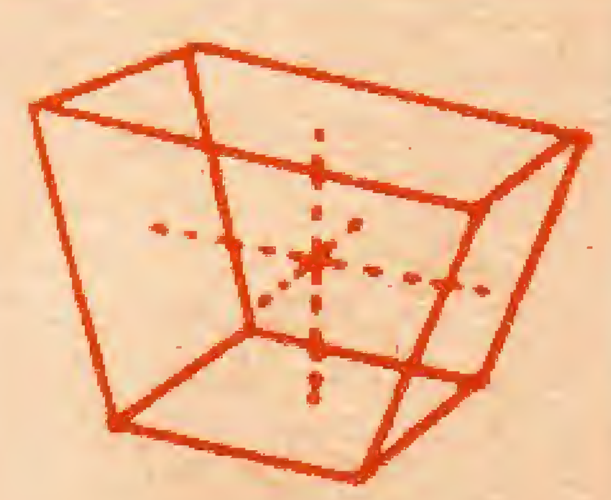
ORTHORHOMBIC

Here the axes are at right angles to each other but of different lengths.



MONOCLINIC

These are crystals with three axes, all of different lengths. Only two of the axes form a right angle.



TRICLINIC

Here the three axes are of different lengths and none of which cuts at right angles.

of water. They formed deposits as this water gradually evaporated. Carbonates, nitrates etc. have also been formed through the same way.

Some minerals like oxides and sulfates have developed from the alteration of pre-existing minerals that have been exposed to weathering. The oxygen contained in air and water often attacks the minerals in rocks, converting them into different compounds.

In some cases, minerals are mechanically broken down into smaller fragments which later accumulate and may be cemented into sedimentary rock. When these are subjected to weathering and erosion, only the most durable and insoluble of the original substances remain, to form deposits like silica, clay, bauxite.

New minerals may be derived from metamorphism—transformations of rocks brought about by heat or pessure or both. In this way crystalline calcite is formed as limestone, silicate is converted into serpentine and so on.

Some minerals take on new colours when exposed to ultraviolet light.

Classification of Minerals

There are many different kinds of minerals. About 1500 varieties are known at the present time. Minerals may be classified, according to the elements of which they consist or the compounds they form, into following eight groups :

(1) *Minerals as elements* such as diamond ; (2) *The sulfides* such as iron pyrites ; (3) *The oxides* such as corundum ; (4) *The sulfates* such as gypsum ; (5) *The carbonates* such as calcite ; (6) *The halides* such as sodium chloride ; (7) *The phosphates* such as apatite ; (8) *The silicates* such as quartz.

It is the knowledge of rocks that has given mankind its material progress

Rock-Forming Minerals

QUARTZ

Rocks are made from one or more kinds of minerals. Of all the rock-forming minerals, the simplest and most widespread is the mineral quartz. It is found in all the big groups of rocks—igneous, sedimentary and metamorphic. Some quartz is colourless. Other colours are white, pink, violet and gray.

FELDSPAR

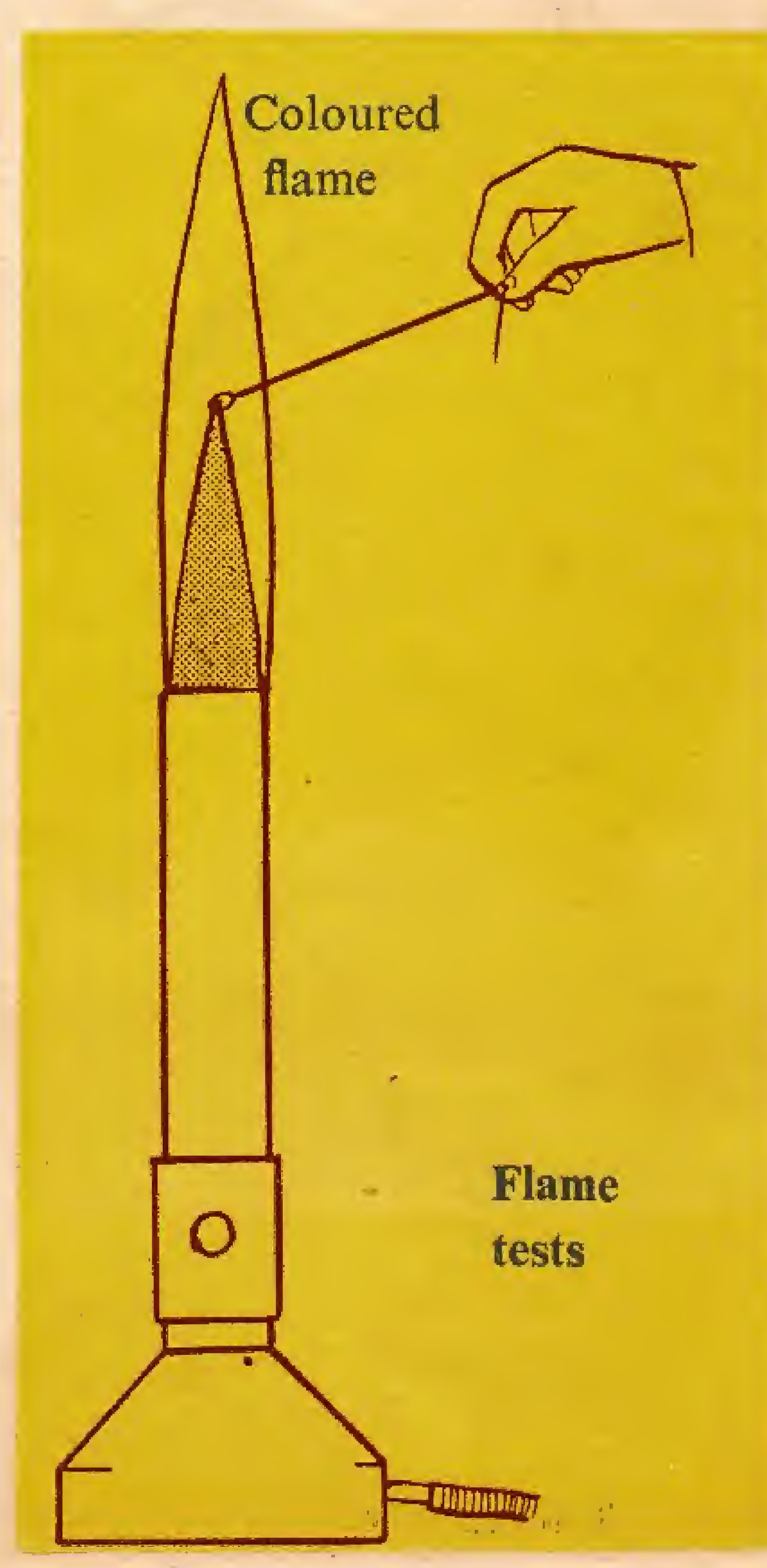
Probably the most important of the rock-forming minerals are the feldspars. The name feldspar is really a family name. That is, it is a name used for six or seven feldspar minerals. All of these feldspar minerals are much alike, sometimes so much so that it is hard to tell them apart. They occur in almost all of the igneous rocks. Most of them are light coloured—white, pinkish, orange or pale blue.

Micas nearly always occur in rocks which have been heated, squeezed or folded.

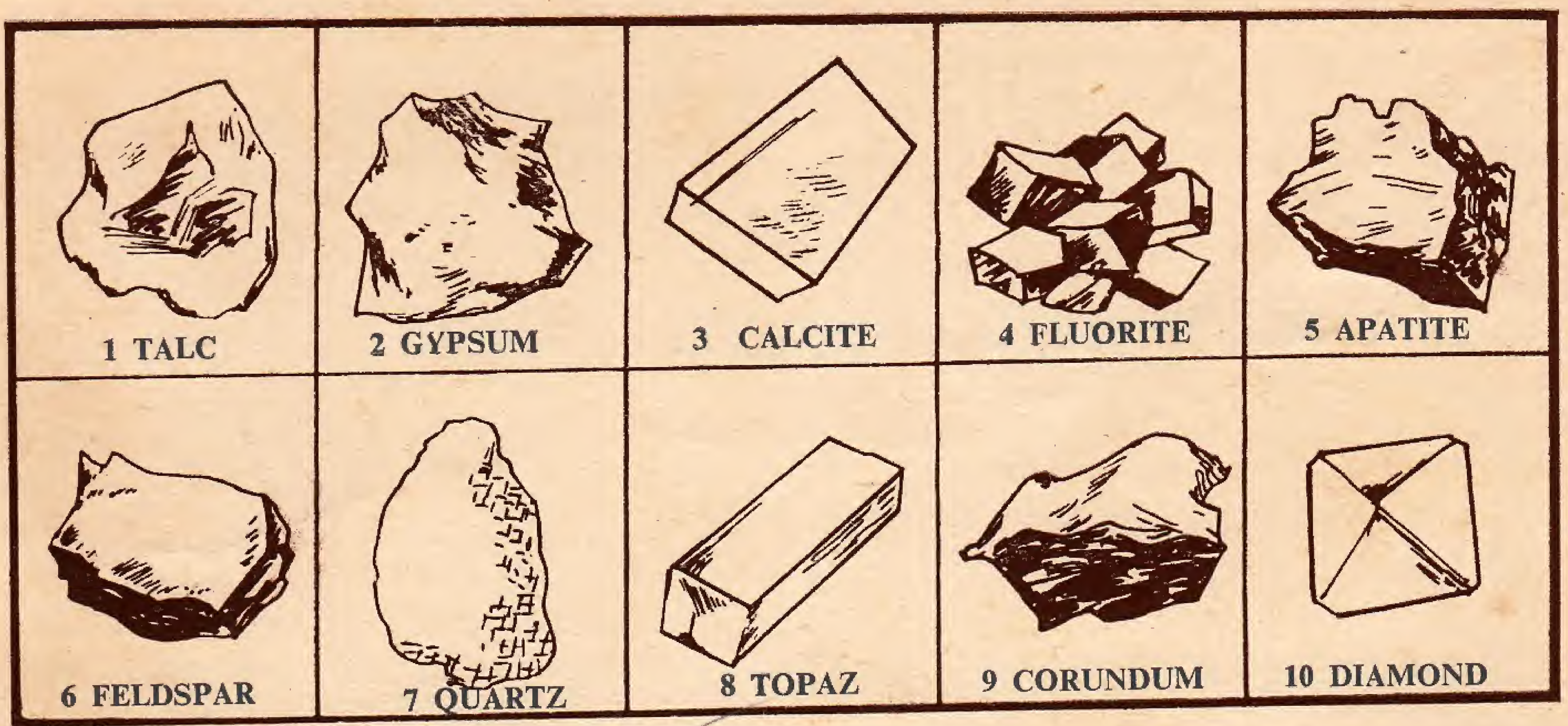
Other important rock-forming minerals are amphiboles, pyroxenes, zeolites, garnets, olivine, chlorite and serpentine.

IDENTIFICATION OF MINERALS

All minerals have a definite chemical composition and definite physical characteristics by which they may be recognised.



In flame test a mineral will colour a flame according to the metal it contains.



Hardness Table

The analysis of crystal formations helps to identify minerals ; but certain other physical properties may be even more useful for this purpose. Among these properties are hardness, light, colour, streak, luster, density, cleavage, parting, fracture, and tenacity.

HARDNESS of a mineral often gives a clue to its identity. If you know how hard or soft a specimen is, it will help you to tell it apart from other minerals.

Various scales of hardness have been developed. The scale proposed in 1822 by the German mineralogist Friedrich Mohs proved to be so practical and so easy to apply that it is still in use.

In the Mohs' scale, certain standard minerals are given a hardness rating from one to ten, as follows :

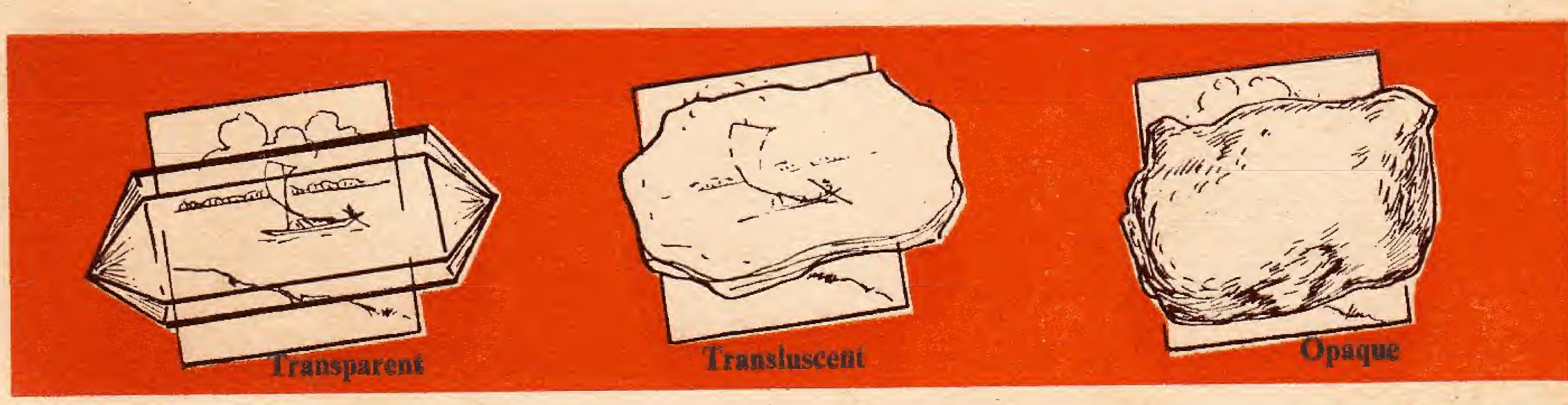
1. *Talc :* is a metamorphic mineral. You can scratch it with your fingernail. It is the softest of the minerals in the scale. Talcum powder is made from this.

2. *Gypsum :* is a sedimentary mineral. This also you can scratch with your fingernail. It may be colourless or white. Plaster of Paris, black-board chalk etc. are made from it.

3. *Calcite :* is a colourless or white mineral found with all groups of rocks. Iceland spar is a special form of calcite.

4. *Fluorite :* may be white, gray, black and many other colours. They may also

Some minerals are transparent, some are transluscent and some are opaque.



be colourless. You can scratch it with a small pocket knife.

5. *Apatite :* forms beautiful crystals of many different colours. Some of these colours are white, brown, green, violet, blue and yellow. Yellow is the most common colour.

6. *Feldspar :* is about the most common mineral on the earth. When this mineral breaks up and rots, it turns into clay. Your knife will not scratch feldspar instead it will scratch your knife.

7. *Quartz :* comes in many colours. A beautiful kind of quartz is named Tiger's Eye and is used in jewellery. Quartz sand is melted and turned into clear glass.

8. *Topaz :* is prized as a gem stone. It is commonly yelow.

9. *Corundum :* some crystals of this mineral are gem stones. Ruby is a clear red corundum crystal.

10. *Diamond :* is the hardest mineral known on earth.

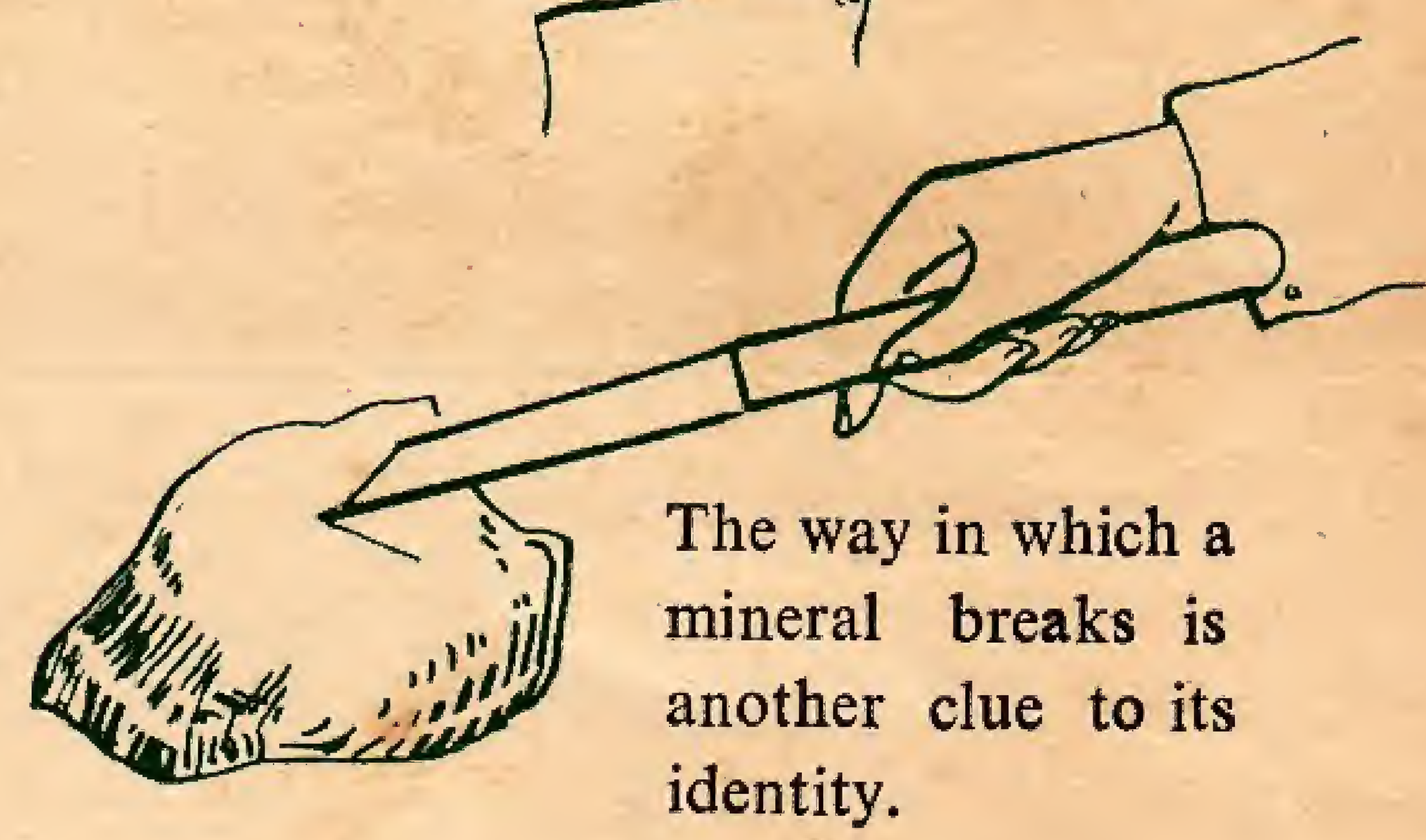
A given mineral in this scale can scratch any mineral with a lower number ; it can be scratched by any mineral with a higher number.

LIGHT : Some minerals are transparent and some are opaque (i.e. no light is transmitted through them at all). There are the other minerals in between, which let through a certain amount of light only.

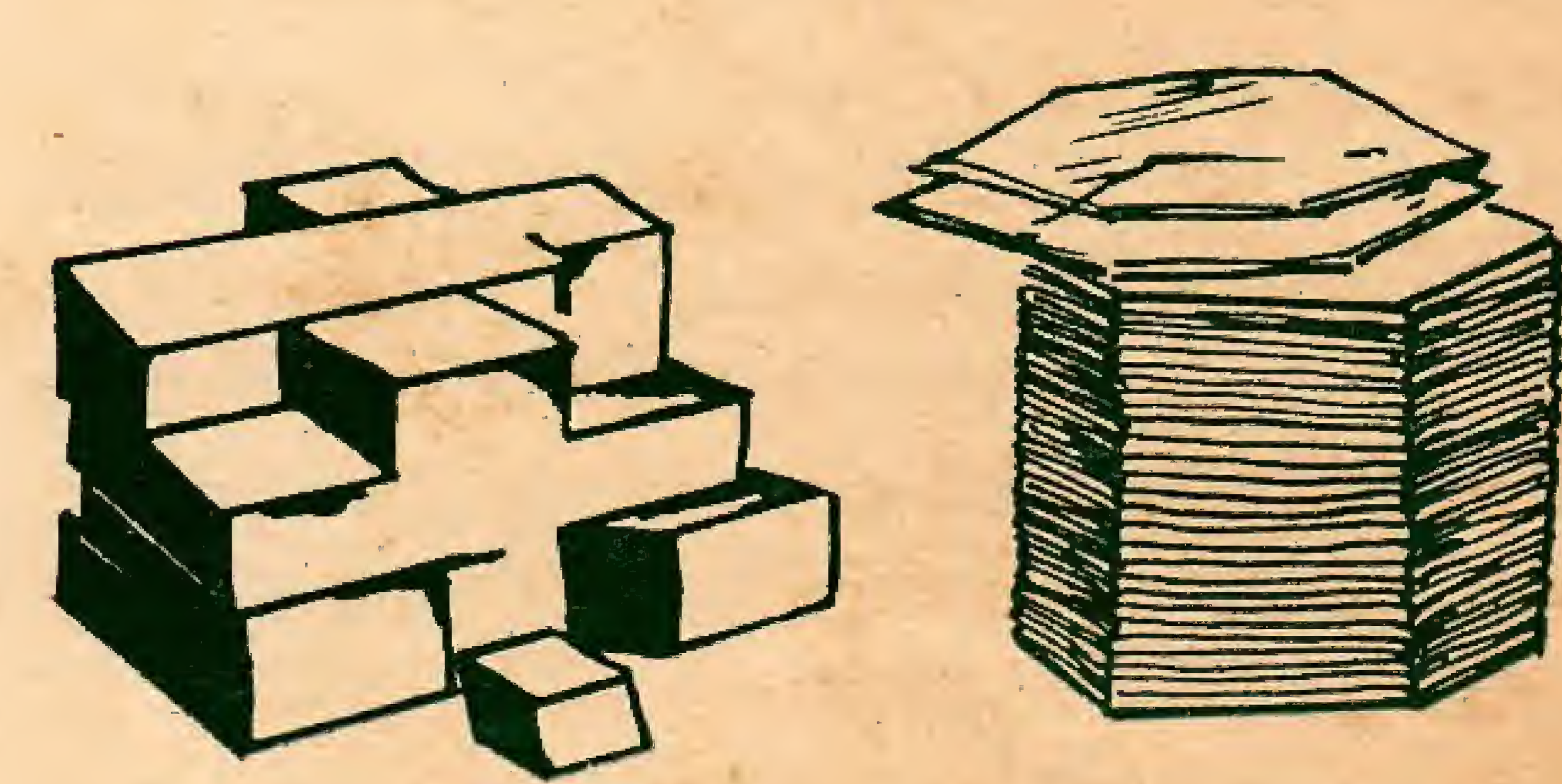
COLOUR may sometimes help identify various minerals. It is not always a reliable guide, however, because of its changeable nature. Some minerals take on new colours when exposed to ultra-violet light and are said to fluorescence.

STREAK of a mineral is related to both colour and hardness. The colour of the streak is often more constant and a more certain means of identification than the colour of the mineral producing the streak.

Harder minerals can scratch the softer ones.



The way in which a mineral breaks is another clue to its identity.



LUSTER or sheen is often useful in determining minerals. It depends upon the amount of light it absorbs or reflects. A mineral may have a metallic, greasy, glassy, resinous, silky, pearly or adamantine (diamondlike) luster.

DENSITY is another distinguishing characteristic of minerals. The density, or weight per unit volume, of a substance

Prospecting for ore deposits by Siesmic method

depends on the weight of the elements of which it consists and also on how closely they are packed in the crystal structure.

CLEAVAGE or splitting also helps identify various minerals. It is the way in which some minerals tend to split along certain flat planes. Cleavage can be revealed by breaking a crystal of the mineral and noting how it splits.

PARTING also involves splitting in a certain plane. However, it is not quite the same thing as cleavage.

FRACTURE or breaking off is not related to any particular plane or internal direction. However, minerals do have a tendency to break apart in a certain way.

TENACITY represents the resistance of a mineral to breaking under force.

CHEMICAL TESTS can be used to diagnose the nature of an unknown mineral. The *flame test* relies upon the fact that a mineral will colour a flame according to the metal it contains.

ELECTRICITY AND MAGNETISM : Metallic minerals are good conductors of electricity whereas the non-metallic minerals are not. All mineral crystals develop an electric charge when rubbed but it can be seen more clearly in some than others.

The only mineral that is strikingly attracted to a magnet is magnetite. Platinum, ilmenite and some other minerals give a half-hearted response to a magnet.

RADIOACTIVITY : All uranium minerals (these are over 100) are radioactive, i. e., they emit radiations which can be detected by a particular device.

HEAT : Different minerals fuse (melt) at different temperatures.

Prospecting For Minerals

Since mineral ore is burried deep under the ground, locating it is not easy. In view of the high cost involved in mining, it is essential to be reasonably sure beforehand that mineral is likely to be found.

A common process for finding ore deposits is called *Seismic* method. In this method, the dynamite charge is put in a hole drilled in the ground. When the dynamite charge is exploded, the shock waves move through the ground. These vibrations reflect back again to the earth's surface, which are picked up by delicate instruments called seismometers. Different types of rock or soil send back the vibrations with different speed. By studying these the experts can determine which areas are worth mining.

Geiger Counter detects the presence of radioactive minerals

Prospecting for radioactive minerals, containing uranium, thorium and radium, involves certain special techniques. Radioactive minerals give off radiation and can be found readily by devices that detect this emission. An instrument called Geiger Counter is used for this purpose. When radioactive rays from an outside source is picked up by this instrument, it produces a loud click.

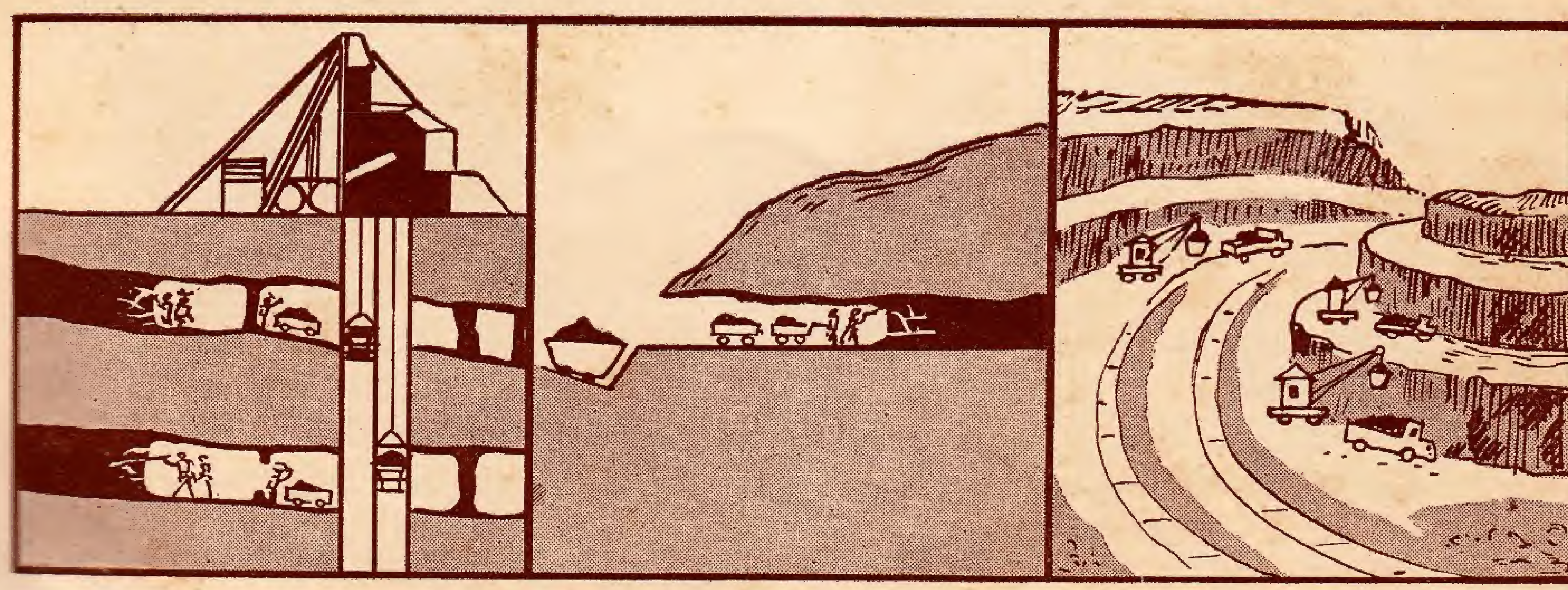
Magnetic methods, gravitational methods, electrical methods are some of the other modern methods of locating valuable hidden deposits.

Different types of mining

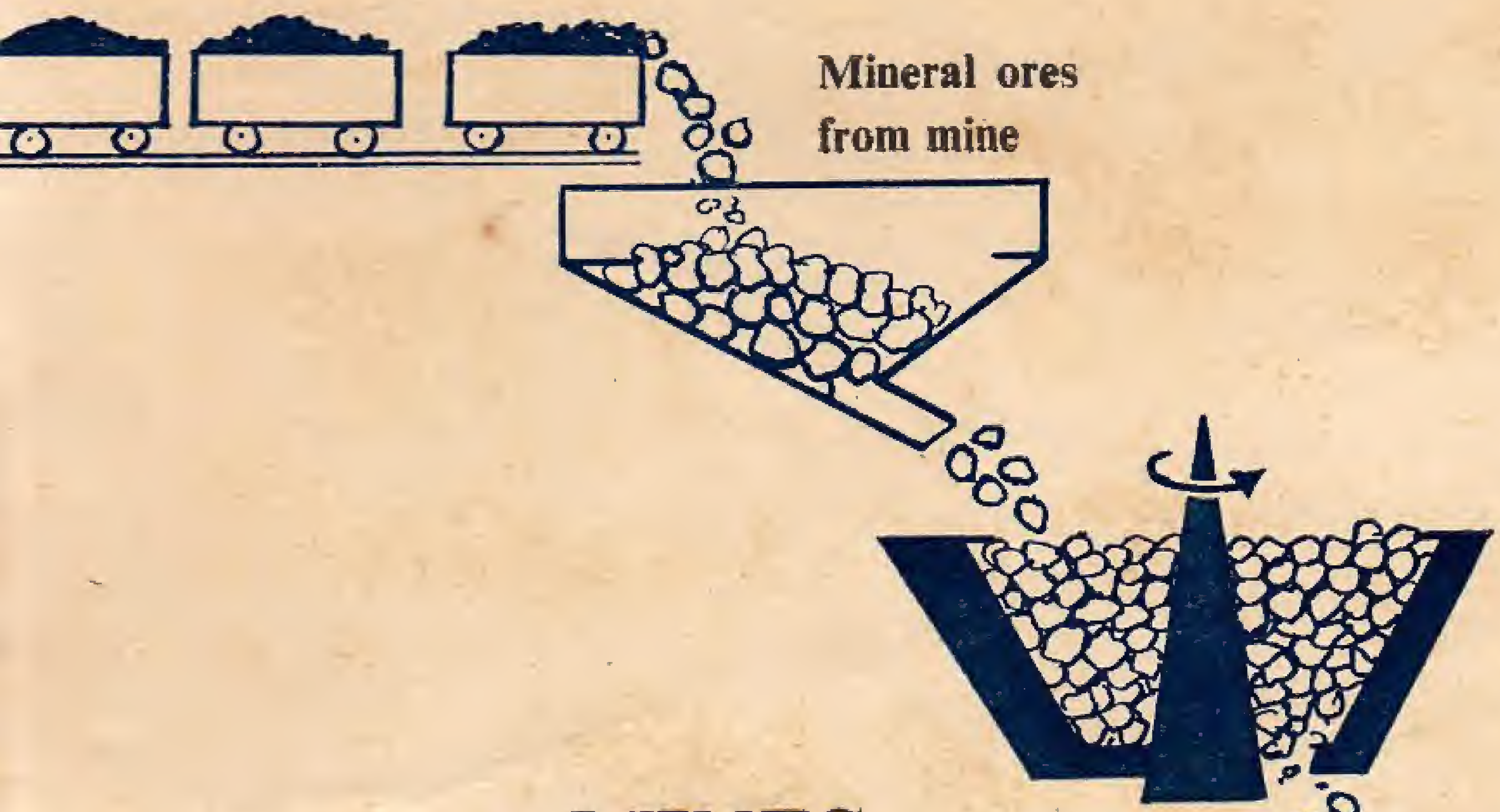
Shaft mining

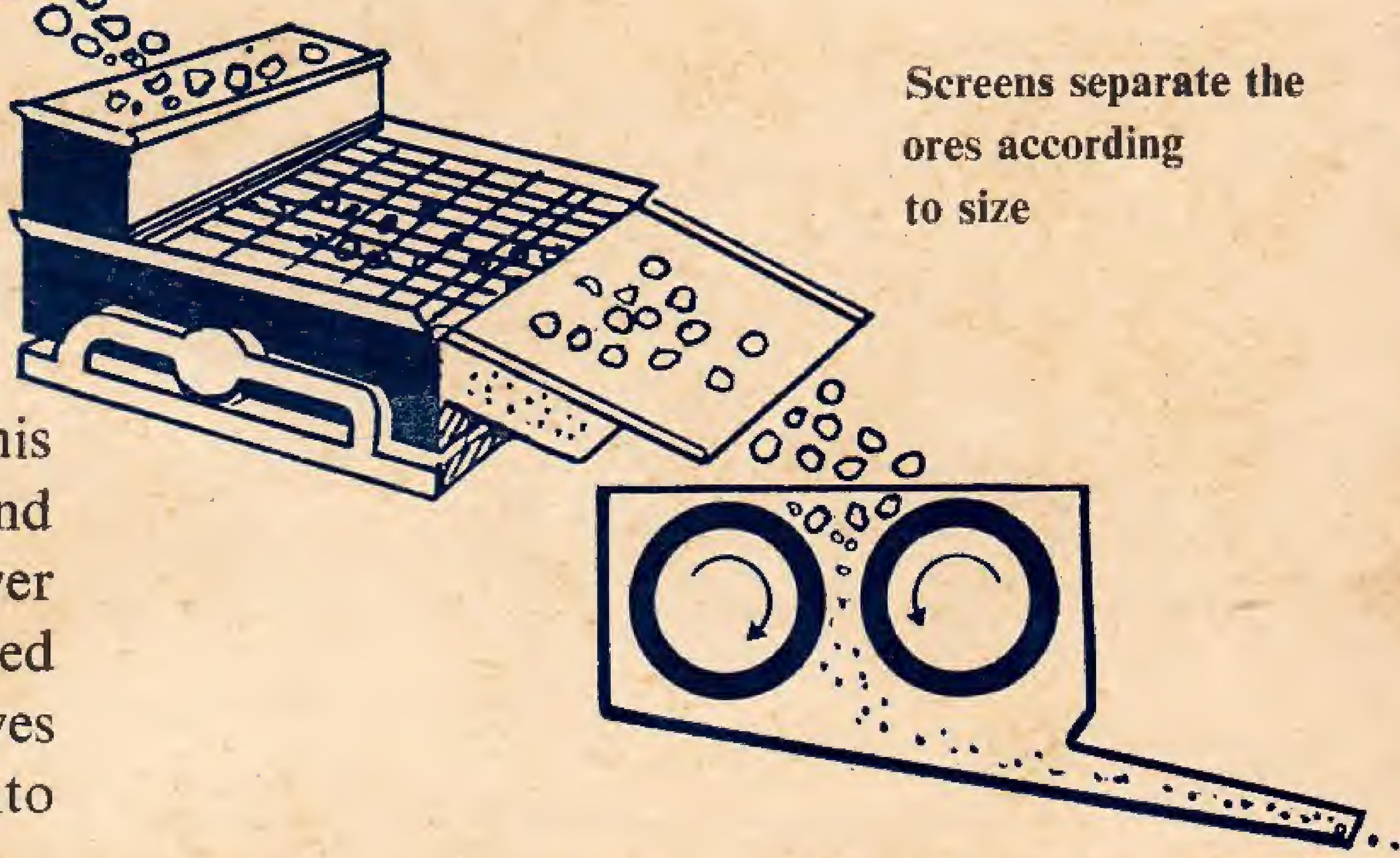
Slope mining

Open-pit mining



This is how the ores are recovered from different impurities





MINES

Ore deposits may occur in various depths under the earth's surface.

If the ore deposit lies close to the earth, it is mined by a method called *stripmining* or *open-pit mining*. In this method, the overlying layers of soil and rock are removed by bulldozers, power shovels and trucks. After the ore bed is reached, it is broken up by explosives and finally is loaded mechanically into trucks for transportation.

Certain ore deposits are too far below the surface for stripping or else they are covered by a thick layer of rock. There are three ways to mine these deposits : *slope mines, drift mines* and *shaft mines.*

Slope mining method is used where ore beds are not deeply buried though not so near as in the case of strip mines. In this method, a tunnel is dug into the ground following a gentle slope until it reaches the ore bed.

In drift mining method, a tunnel is dug into the bed, located in the side of the hill.

In the shaft mining method, one goes down into it through a great opening, called a shaft, a hole that is dug straight down to the earth. The shafts are dug into the ground to reach the lowest layer of ore.

DRESSING

The prime object of ore dressing is to separate, by mechanical means, the valuable minerals from the different impurities.

Ore may come from the mine in a wide range of sizes. It is sent to the mill and is subjected to various crushing devices. At various stages of the crushing operations, materials are separated, according to sizes, by means of screens. It is a device, consisting of parallel bars, or rails, so spaced as to permit material of small size to fall through the openings, while the larger chunks are kept on the rails. The different stages of ore dressing is shown in the diagram.

The finer materials are reduced to smaller size by various types of grinders. The material to be ground is fed into the mill and is crushed. Then it is screened again and passed directly to the shaking table, called vanners. A jerking action is employed to convey the heavy grains to one side, while a current of surface water washes the lighter graines to the other side.

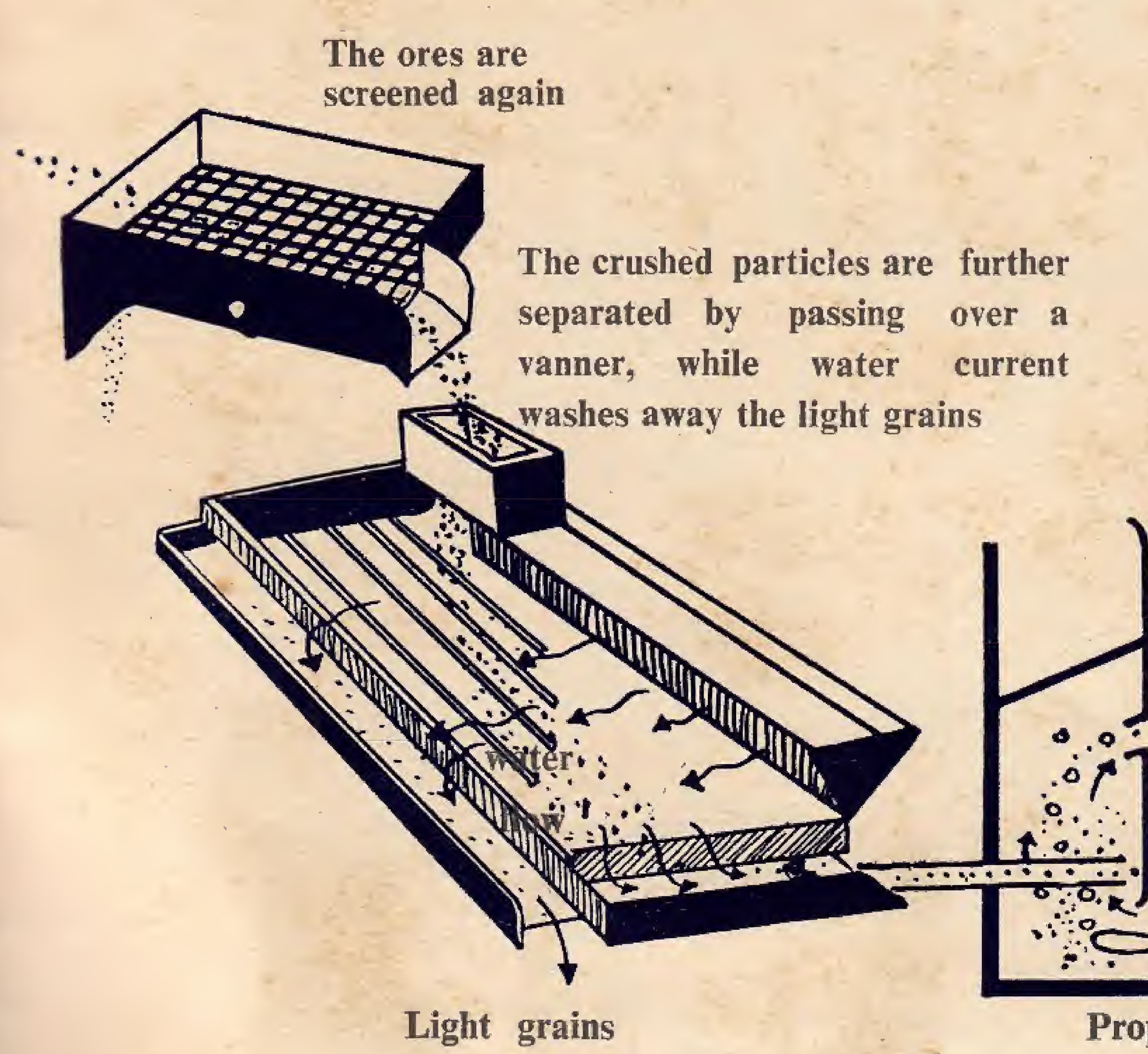
Then the ore goes under another process called floatation. It takes place in a tank, called a floatation cell. Into it are introduced finely divided mineral particles, water, a substance of a more or less oily nature and certain chemicals. The ingredients are stirred vigorously by a rapidly revolving propeller, and an oily foam is produced. The mineral particles adhere to the bubbles of which the foam consists ; the particles which do not adhere to the bubbles sink to the bottom of the cell. As the mineral-bearing foam rises to the surface of the floatation cell, it is scrapped off by paddles into a trough, called a launder.

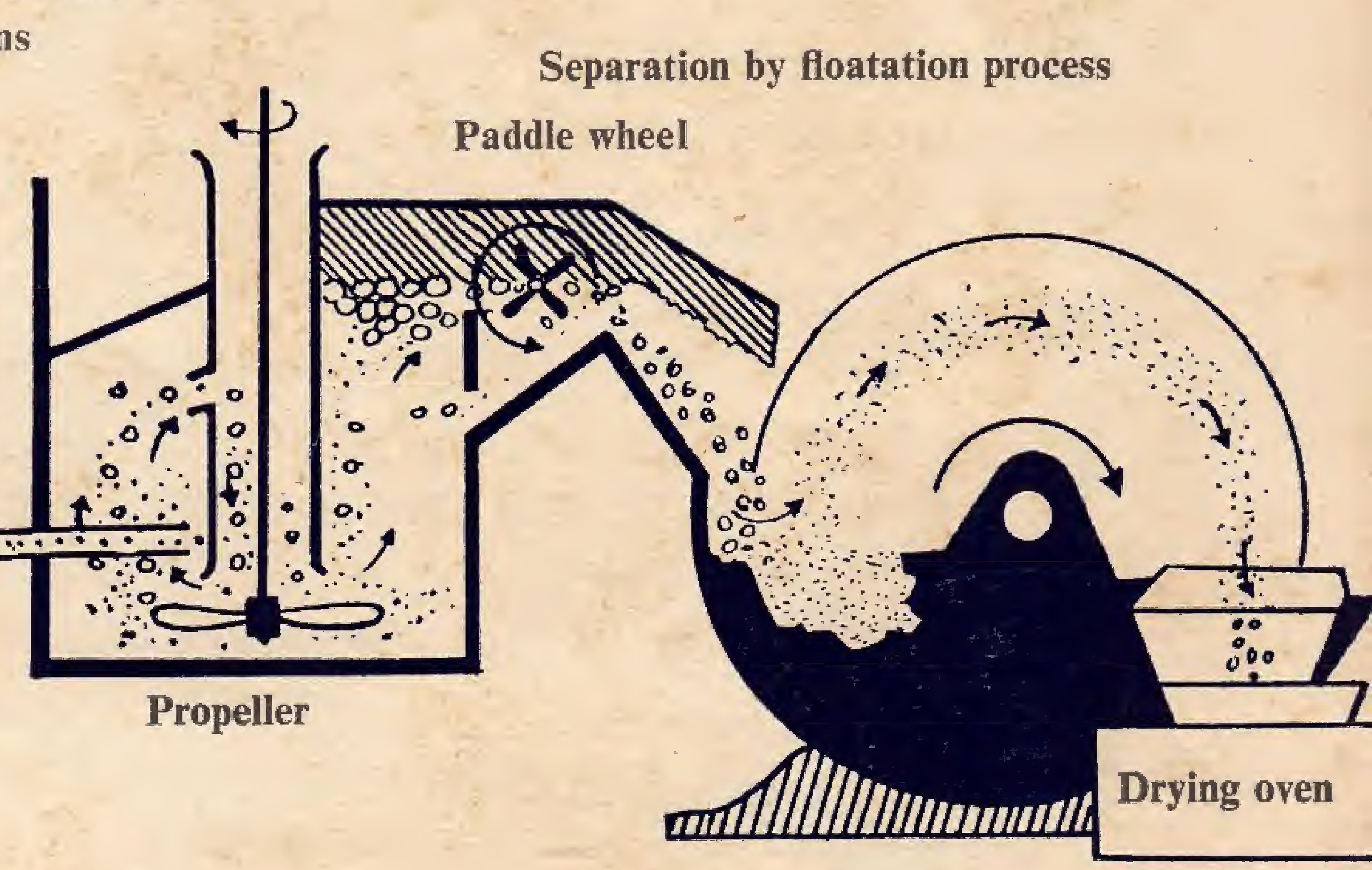
The launder delivers the product to a special filtering device and from there it is passed to a drying oven.

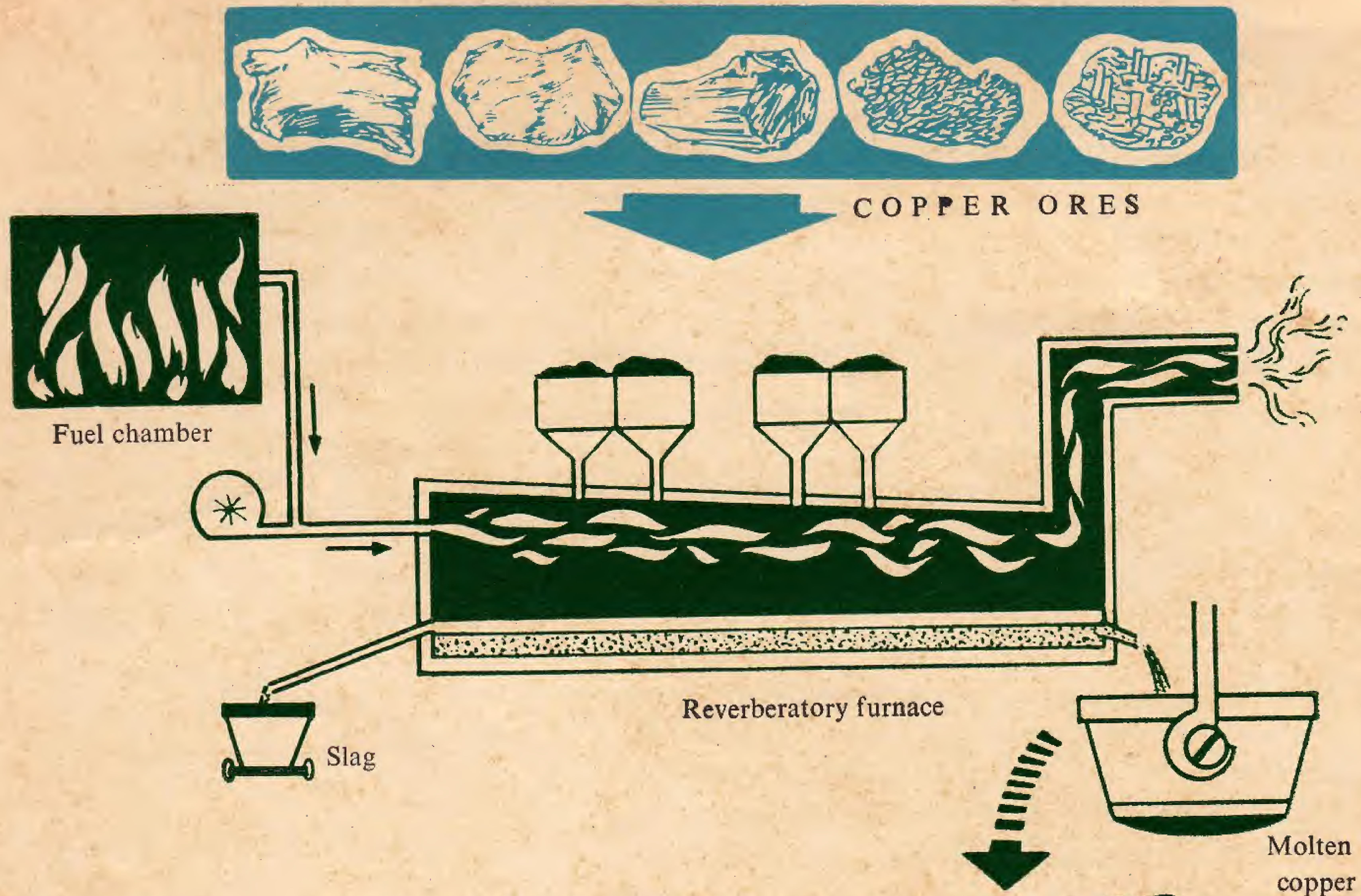
Numerous other methods are there to separate minerals. The method called magnetic separation is used to separate metals like iron, nickel, cobalt etc. It is based on the fact that most substances are either attracted or repelled by a magnet.

SMELTING

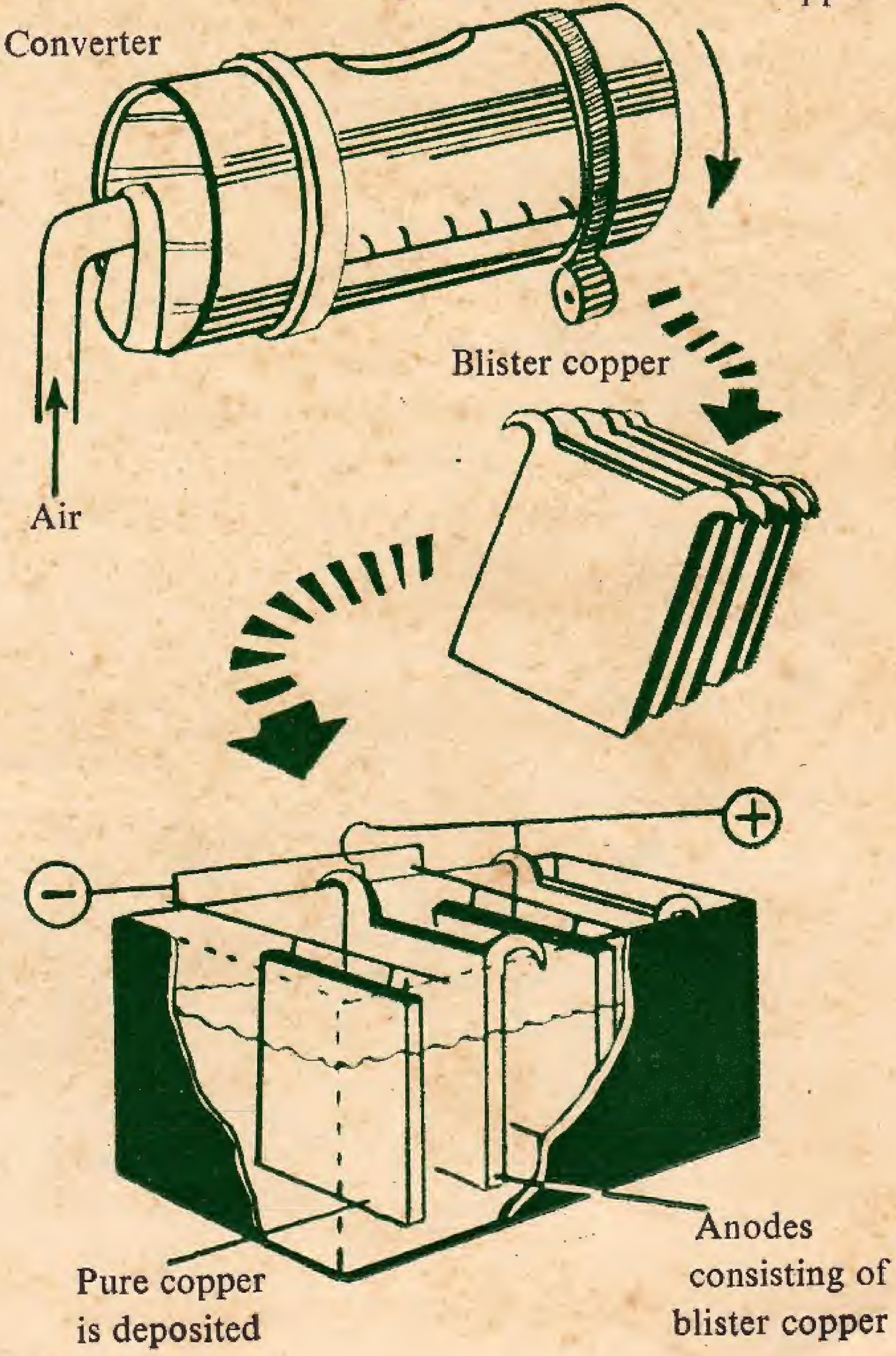
After mineral ore is relieved of its impurities, it is subjected to another process by which metals are extracted from their ores. This process is known as *smelting*. In general, smelting includes various heating processes to remove the unwanted materials.







Process of smelting is divided into two broad classifications. One process applies to ferrous minerals in which iron is recovered from its ore. The other process is concerned with non-ferrous minerals that is recovery of common metals other than iron—metals such as copper, zinc, lead etc. Different process of smelting is adopted to extract different metal. Here we have discussed about smelting of copper.



Smelting of Copper

A reverberatory furnace, as shown in the picture, is used in copper smelting which consists of a horizontal hearth. Ore and flux are placed in it and subjected to the action of flames from an adjacent fuel chamber. As a result, two different molten layers are formed—one is called slag containing the impurities and the

other is called he matte containing the valuable mineral matter. The slag and matte are separated. The molten matte is drawn off and passes into ladles and from there goes to a heated converter. There the iron and sulfur are removed from the matte by forcing air into the liquid mass. After the process is complete, the converter can be tilted to pour out slag and molten copper.

This molten metal, called blister copper, is cast into cakes which is almost pure. Further refining is achieved by electrolytic process. In this process, a rectangular tank is used containing a solution through which electric current can be passed. Blister copper plates are suspended in the tank. They are connected to the positive terminal of the battery forming the anode. As electric current is passed through the tank the anode is gradually dissolved and pure copper is deposited on the cathode.

The cathode copper is cut into suitable forms for various use.

Copper wires are extensively used for transmission lines

Rocks In Our Lives

Today rocks are used nearly everywhere. The weathered rock becomes the soil on which we depend for crops, forests and grasslands. The fertilizers we add to the soil come mainly from rocks.

The fuels we use come from rocks. Coal, oil, and natural gas are found in sedimentary rocks ; atomic fuels come from the rocks, also.

We are equally dependent on the rocks for all the metals we use—iron, copper, lead, tin, zinc, gold, silver and all other metals.

Steel, the most versatile material of the modern world, comes from the iron. In fact it is the use and development of metals that has given man's material progress.

Apart from metals, rocks are widely used for everything from building homes, huge dams and roads to delicate porcelain utensils.

Glass, which is another important product man has developed, comes from rocks. The ingredients from which glass is made are sand, limestone and soda.

Many rocks are prized for their beauty such as diamond, ruby etc.

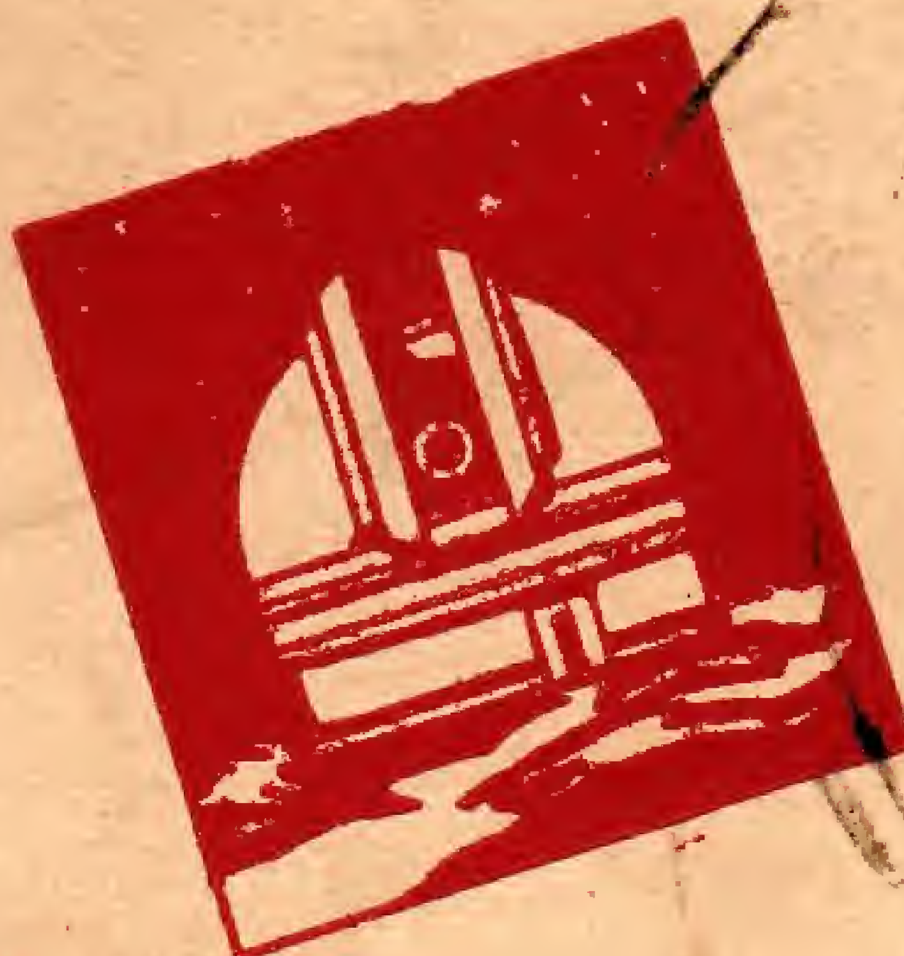
The real beauty of rocks lies in the variety they give to the surface of the earth. It has created the majestic peak of Himalayas as well as the loneliness of the Sahara.

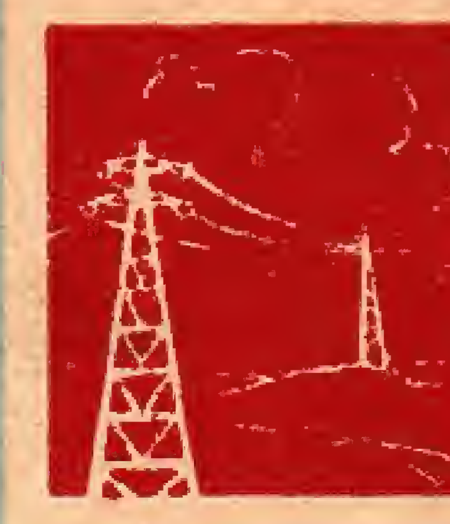
As a matter of fact, we will still be depending on the rocks in the earth even when we reach the moon or when space travel becomes an everyday occurrence.

Regd. C—290 16th Nov 64

HOW ? WHY ? WHAT ?

SACHITRA BIGYAN KOSH





JATIYA SANSKRITI PARISHAD

Publication Plan for 1964-65

2001 **Rockets and Satellites**
2002 **Aeroplane**
2003 **Telephone and Telegraph**
2004 **Space Travel**
2005 **Story of Steel**
2006 **Electricity**
2007 **Story of Coal and Petroleum**
2008 **Introduction to Light**
2009 **The Automobile**
2010 **Radio**
2011 **Story of Minerals and Metals**
2012 **Fire and heat**
2013 **The story of locomotive**
2014 **Paper making and Printing**
2015 **Sound and its recording**
2016 **Story of Glass and Rubber**
2017 **The wonders of the Atom**
2018 **Work and Power through Machines**
2019 **Ships and Submarines**
2020 **Television and Radar**
2021 **The Forces of Nature**
2022 **Electricity in use**
2023 **The wonders of modern Chemistry**
2024 **Photography and Cinema**